Study Report 93-03

A Multiperiod Model of U.S. Army Officer Retention Decisions

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This report describes a study on the determinants of officer retention behavior. Stay-leave decisions for field-grade active-duty officers in the Infantry and Signal Corps branches were examined using multiperiod ACOL-2 models. This effort expanded upon a pilot study involving the Air Defense Artillery branch. A multiperiod model that predicts officer career decisions as a function of economic, demographic, and Army personnel policies (e.g., military compensation) was successfully estimated with longitudinal data from the U.S. Army Research Institute for the Behavioral and Social Sciences Officer Longitudinal Research Data Base. The estimation showed that financial incentives exerted strong behavioral influence on retention, although there is evidence that the strength varies by branch. Civilian labor market conditions, as measured by the unemployment rate, had a significant effect on career decisions. Retention behavior also varied by source of commission, gender, race, and marital status. Finally, unobserved hererogeneity had a significant impact: as officer cohorts age, the distribution of unobserved tastes for the military becomes truncated and retention rates rise.

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This study also explored options for the design of a PC-based Officer Personnel Inventory, Cost, and Compensation (OPICC) policy analysis model. The report presents a proposed structure, along with a discussion of modeling tradeoffs necessary to balance policymaker analytical needs and costs. The proposed structure for the OPICC model consists of three integrated modules: (a) a policy module that translates policy and other changes into changes in retention rates using econometric research results; (b) an inventory projection module that reflects the manpower effects of the policy changes; and (c) a cost module, using the Army Manpower Cost System (AMCOS) methodology, to capture the resources impact of policy changes.

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FOREWORD

The Manpower and Personnel Policy Research Technical Area (MPPRTA) of the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) performs research and studies on the economics of manpower and personnel issues of particular significance to the U.S. Army. This project developed and estimated a multiperiod ACOL-2 econometric model of the retention decision of field-grade, active-duty officers in the Infantry (IN) and Signal Corps (SC) branches. This study expanded upon a pilot study involving the Air Defense Artillery (ADA) branch and also developed the preliminary structure for a policy analysis system to evaluate changes in officer personnel policy.

ARI's participation in this effort is part of an ongoing program of research and studies designed to enhance the quality of Army officer personnel. This work is an essential part of the mission of ARI's MPPRTA to conduct research and studies to improve the Army's ability to effectively and efficiently manage the force.

EDGAR M. JOHNSON
Acting Director

A MULTIPERIOD MODEL OF U.S. ARMY OFFICER RETENTION DECISIONS

EXECUTIVE SUMMARY

Requirement:

The U.S. Army must be able to measure the effects of personnel policy options and changes on the size, shape and cost of its officer force. An Officer Personnel, Inventory, Cost, and Compensation (OPICC) model will improve the Army's ability to effectively and efficiently manage the officer force. It will provide policymakers with timely and accurate information about the impact of policy changes, including changes in end strength, number of accessions, promotion policy, compensation, and separation incentives. This type of model also projects the size and skill composition of the officer force and estimates the cost of manpower to the Army. The model contains econometric estimates that quantify officer responsiveness to policy and environmental factors.

Procedure:

Information about the manpower costs and effects of personnel policy and other factors on the retention of high-quality active-duty commissioned officers, both for the aggregate Army and at the branch level, is critical to the development of the human resources necessary for an effective officer force. The ACOL-2 model, a dynamic structural econometric model of the decision to stay in or leave the military as an occupation, is a recent advance in military manpower research that improves the evaluation of personnel policy changes. This study extends and expands upon previous work by designing and estimating a multiperiod ACOL-2 model that can be used to evaluate the effects of personnel policy on the retention of officers in the Infantry (IN) and Signal Corps (SC) branches.

Findings:

A multiperiod model that predicts officer career decisions as a function of economic, demographic, and Army personnel policy (e.g., military compensation) influences was successfully estimated with longitudinal data from ARI's Officer Longitudinal Research Data Base (OLRDB). The model estimates yielded highly (statistically) significant pay and unemployment effects in the expected directions. The findings also showed that fixed, unobserved preferences for Army service exert a great deal of

influence on observed retention behavior. The model specification included improved identification of officers' initial active-duty obligations.

The study also explored options for design of the OPICC model. A proposed structure is presented, along with a discussion of modeling tradeoffs necessary to optimize the model to address policymaker analytical needs.

Utilization of Findings:

This study demonstrates the applicability of the ACOL-2 methodology to modeling officer retention in different Army branches or communities. It also presents a feasible preliminary design for the OPICC model that incorporates econometric research findings and allows for modular expansion as new research findings become available.

A MULTIPERIOD MODEL OF U.S. ARMY OFFICER RETENTION DECISIONS

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A MULTIPERIOD MODEL OF U.S. ARMY OFFICER RETENTION DECISIONS

INTRODUCTION

The U.S. Army faces a critical juncture in the management of its active-duty commissioned officers. The reduction in external security threats coupled with continuing pressure to reduce the federal budget deficit will inevitably lead to a smaller Army officer corps in the 1990s. While the demand for active-duty officers will decline in the aggregate, individual units in a smaller force must be more flexible and capable of a wider range of tasks and operations. A large number of units specialized to specific functions will be a luxury of the larger force sizes of the past.

The irony is that in this era of "downsizing" the Armed Forces, well-reasoned retention policies that continue to make the Army attractive to high-quality, top-performing officers become more important than ever. The Army's ability to measure the performance and potential of officers, and its ability to devise retention policies and programs that keep the most talented in the Army while remaining within constrained budget ceilings, will be severely tested.

To provide the Army with tools to analyze some of the major policy issues facing the officer corps in the 1990's, the U.S. Army Research Institute has sponsored studies of officer retention behavior. The initial study explored the feasibility of estimating a model of Army officer retention. Mairs, *et. al.* (1992) estimated a model of Army officer retention behavior over two retention decision points for the Air Defense Artillery (ADA) Branch. This initial study, perhaps the first attempt to estimate a model of Army officer retention, provided statistically significant estimates of the response of officers in the Air Defense Artillery community to changes in relative pay and unemployment. The results of this pilot study also indicated that retention rates varied significantly with the demographic characteristics of the officers.

In this report, results of a second study of Army officer retention are presented. Retention models for the Infantry Branch and the Signal Corps are estimated. Moreover, the model and data represent an improvement over that of the study of the ADA branch. In particular, the two-period decision framework applied in the ADA study is expanded to a multiple decision framework. The model is able to predict annual retention rates for junior officers from the end of their initial service obligation (typically year of service three or four) through the period prior to promotion to Major (typically year of service eleven). Better data regarding when officers have satisfied their initial obligation and are free to make a voluntary decision to stay or leave make this richer framework possible.

The ultimate purpose of developing econometric models of Army officer retention behavior is to imbed them in an analysis tool for examining officer issues and policies. In this report, a design for the Officer Personnel, Inventory, Cost, and Compensation (OPICC) Model is presented. Its purpose is to help the Army plan for, and successfully meet, the officer personnel management challenges of the next ten years. This model will project the inventory of the officer force, in the aggregate or by selected community, over time. It will have a behavioral component derived from the econometric models of retention allowing the analyst to adjust retention and inventory levels for the effects of changes in relative compensation and unemployment. In addition, the effects of changes in promotion rates, early release programs, and other policies can be examined. A final component will provide estimates of the cost of the resulting officer force levels, including MPA cost elements, training costs, and costs associated with rotation policies. In principle, the model will help answer questions such as:

- What is the likely effect of 15 year retirement vesting on officer retention patterns, experience levels, and costs?
- How many MPA budget dollars will a one year delay in promotion to Major save? What is the likely effect on retention and officer inventories?
- What is the likely effect on retention, inventory, and costs of expanding VSI/SSB eligibility?

This report presents the results of the retention analysis for the Infantry and Signal Corps, and a design outline for the OPICC Model. The major sections include

1. Theory: an overview of the model's conceptual framework
2. Econometric Model: a discussion of the method used to estimate the model
3. Data: a description of the primary data set and a review of data issues that arose in the course of this study
4. Findings: the estimated model parameters and interpretation of their effects
5. OPICC Model: the outline of the design of an officer personnel policy analysis model, and a plan for developing the model in modular components
6. Conclusions: a summary of the major findings, their implications for policy analysis, and their relevance for further research and studies.

THEORY

Behavioral retention models estimate the effects of pay changes and economic conditions on the propensity of individuals to remain in the military. These models are grounded in the economics literature on occupational choice. Most military retention studies assume a two-choice world in which an individual may choose employment in the military or employment in civilian occupations.

A crucial issue which retention models must address is the horizon problem. That is, over what horizon should two occupational alternatives be compared? This issue is especially important because of the influence of the retirement system. If a member completes 20 years of active duty service, he or she is eligible for an immediate, substantial annuity upon leaving service. However, in the general case, no annuity is received if the member leaves with fewer than twenty years of service. Whether or not a member's decision horizon is assumed to incorporate the twenty year of service point has a substantial effect on the measured incentive to stay in service. The Annualized Cost of Leaving (ACOL) model provides a consistent, non-arbitrary solution to this question: the horizon is chosen for which the annual difference between military and civilian pay is largest. If the individual will not stay for this horizon, he or she will not stay for any horizon that implies a less generous rate of military pay relative to civilian alternatives. There are other models that dynamically consider multiple horizons simultaneously in a rational way, but they are less tractable both in estimation and in application to policy.

Retention models must also account for changes in cohort behavior over time. Cohort retention rates rise with tenure for two principal reasons.[1] First, an individual accumulates firm-specific human capital with tenure. This capital has no value to other employers; the employee would forfeit it upon quitting. Retention rates also rise with tenure simply because those who have a relatively high "taste" for Army life will tend to stay at higher rates than those who do not. That is, the underlying distribution of unobservable factors affecting retention behavior systematically changes as cohorts pass through decision points. This phenomenon is referred to as "taste censoring" or "unobserved heterogeneity" in the econometrics literature.

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[1]In the case of military service, a third reason for increases in tenure with years of service is the nature of the retirement system, which provides an increasingly powerful incentive to stay through twenty years of service, as the twenty year point is approached. Clearly, part of the retirement incentive is to encourage the retention of members who have accumulated significant firm-specific capital. However, it undoubtedly provides an incentive that is greater than can be explained solely as compensation for the accumulation of firm-specific capital.

This section summarizes the utility-maximization model of retention decisions faced by Army officers used in this study. It begins with a brief survey of related studies and discusses the application of this approach to the retention decision of Army officers in the Infantry (IN) and Signal Corps (SC) branches. Finally, the section describes the construction of the key explanatory variable: the Annualized Cost of Leaving (ACOL).

Review of the Literature

Research on retention in the Department of Defense is currently at the frontiers of economic models of occupational choice. However, there has been less research conducted on officer retention behavior than enlisted retention. Three models are prominent: the Annualized Cost of Leaving (ACOL) model; the ACOL-2 model, which is estimated as a panel probit and explicitly controls self-selection as members progress through the personnel system; and the Dynamic Retention Model (DRM) developed by Gotz and McCall (1983).

The simple ACOL model has been estimated for enlisted retention behavior in the Navy (Warner and Goldberg (1984)) and for each of the military Services in the aggregate (Enns, Nelson and Warner (1984)). Hogan and Goon (1989) also estimated a version for Air Force officers. The Gotz-McCall model was originally estimated for Air Force captains. Gotz and McCall (1983) provide the theory. The estimated parameters of the model were not published, however. It was later "calibrated" for Air Force enlisted personnel by Arguden (1986). The ACOL-2 model was estimated for both Navy and Army enlisted personnel (Black, Hogan and Sylwester (1987) and Smith, Sylwester and Villa (1991)). It was estimated for DoD civilians by Black, Moffitt and Warner (1990).

Mairs, *et. al.* (1992) were the first to estimate an ACOL-2 model for the officer force. This effort also constituted one of the few attempts to estimate a retention model for Army officers. They estimated a retention model for the Air Defense Artillery branch. The model, which suggested that econometric models of Army officer retention behavior were feasible and had potential relevance to policy decisions, had two shortcomings. First, the crucial initial decision point for officer retention, the end of the initial service obligation, had to be inferred from the officer's source of commission. While this inference was valid for a large majority of the observations, error was undoubtedly introduced in some cases. Second, the model was estimated as a bivariate probit model. Hence, only two decision points could be analyzed.[2]

[2]In addition, as a consequence of both (a) potential error in distinguishing the end of the initial term of obligated service and (b) the limit of two decision points, the time period for calculating the hazard rate was lengthened from the traditional one-year retention rate to a three year period. This makes it difficult to compare the results directly with other

Each method has strengths and weaknesses. The ACOL-2 model and the Gotz-McCall model explicitly control for unobserved heterogeneity—the self-selection that occurs as retention rates rise with tenure. Failure to control for unobserved differences may lead to biased parameter estimates.[3] The ACOL-2 model has the advantage of being easier to estimate and use in policy simulations. This study estimates an ACOL-2 model for Army officers in the Infantry (IN) and the Signal Corps (SC). It improves upon the model estimated for the Air Defense Artillery branch because the data contain better information regarding the initial period of obligated service for the officers.[4] The model has also been expanded from a two period decisions model to an n-period panel probit, made tractable by a numerical integration technique initially applied to this problem by Butler and Moffitt (1982).

Economic Model of Occupational Choice

Economic models of retention behavior assume that individuals seek to maximize utility by choosing either to stay in the Army or leave for the civilian sector. Utility, in turn, depends on pecuniary and non-pecuniary factors. Pecuniary influences consist of military pay and civilian earnings opportunities. Non-pecuniary factors include preference for military service; hardship associated with a duty station; and family separation.

Models of occupational choice predict that an individual chooses a career path to maximize the present value of future potential returns across his/her entire working life. In the context of an Army officer retention model, this framework compares an officer's expected time path of pecuniary and non-pecuniary returns if he/she stays in the Army to the corresponding expected time path of returns to leaving immediately. The ACOL model attempts to measure these effects quantitatively. Specifically, it measures the annualized net benefit of staying in the military versus leaving immediately.

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results in the literature, and potentially introduces additional measurement error, since the explanatory variables are measured at the mean of the period over which the hazard is computed.

[3]Hogan and Goon (1989) estimated a version of the simpler ACOL model for Air Force officers by occupational specialty, using other variables to control for censoring in the error structure, and found that these variables worked well.

[4]The Procurement Program Number (PPN) code, which indicates the program under which the officer entered the Army, and the initial obligation incurred because of that program, has been added to the Officer Longitudinal Data Base (OLRDB), reducing errors in determining initial obligation.

Individual Utility Maximization. Economic models of occupational choice applied to military retention decisions assume that individuals rank jobs based on the pecuniary and non-pecuniary aspects of those jobs, and choose a job, or time path of jobs, that provides the greatest satisfaction or utility over the individual's lifetime.[5]

The utility function that describes the individual's preferences (or values) for various job characteristics typically includes measures of current and expected future military and civilian pay and measures describing the value of non-pecuniary conditions of military service (e.g., rotation frequency, hours of work). The value of the i^{th} attribute of an Army job is represented by $X_{i,A}$ and the value of the i^{th} attribute of the best civilian career opportunity is represented by $X_{i,C}$. According to this model, an individual reenlists if:

$$U(X_{1,A},\ldots,X_{n,A}) > U(X_{1,C},\ldots,X_{n,C}) \ . \tag{1}$$

Random Utility Model. The function U(...) is not, of course, known to the researcher, nor are all the factors that affect a member's decision known and measurable by the researcher. One popular empirical formulation that makes assumptions concerning this "ignorance" and incorporates it into the model is the "random utility" model. An assumption concerning an explicit functional form of the utility function is made, along with an assumption concerning an unobservable random component. For example, a linear utility function results in the following model:

Individual j will stay if and only if:

$$X_{j,A}\beta + \gamma_{j,A} > X_{j,C}\beta + \gamma_{j,C} \tag{2}$$

or

$$(X_{j,A} - X_{j,C})\beta > \gamma_{j,C} - \gamma_{j,A} \ . \tag{3}$$

where $X_{j,A}$ is a vector of characteristics associated with an Army job and $X_{j,C}$ is a vector of characteristics associated with the best civilian alternative; β is a vector of coefficients to be estimated and the γs represent unobservable (to the researcher) aspects of the utility or satisfaction associated with Army and civilian alternatives. This difference, $\gamma_{j,C} - \gamma_{j,A}$, is represented by the variable γ_j, which is distributed over the

[5]See, for example, Smith, *et. al.* (1991); Black and Hogan (1987); Hogan and Goon (1989); and, for a review of current methods and research issues, Hogan and Black (1991).

population of potential stayers according to $f(\gamma)$.[6] Then, the probability that individual j stays is:

$$Prob\left[(X_{j,A} - X_{j,C})\beta > \gamma_j\right] = \int_{-\infty}^{(X_{j,A}-X_{j,C})\beta} f(\gamma)\,d\gamma \ . \tag{4}$$

If γ is distributed $N(0,\sigma_\gamma)$, then

$$Prob\left[(X_{j,A} - X_{j,C})\beta > \gamma_j\right] = \int_{-\infty}^{(X_{j,A}-X_{j,C})\beta/\sigma} f'(\gamma')\,d\gamma' \ , \tag{5}$$

where γ' is a standard normal random variable. This model can be estimated as a probit.

ACOL Model. The Annualized Cost of Leaving Model (ACOL) is derived from this random utility framework simply by specifying that the individual considers the entire future time path of military and civilian income in a rational way. In particular, the differences in the *X*s representing military and civilian pay are replaced by the annualized, or annuitized, difference of the present value of these variables calculated over a horizon which maximizes the annualized difference. The decision rule becomes, stay at time *t* if and only if

$$ACOL_{j,t} + Z_{j,t}\beta > \gamma_{j,t} \ , \tag{6}$$

where $Z_{j,t}$ represents the net difference between other Army job and civilian alternative characteristics $(X_A - X_C)$.

ACOL-2 (Panel Probit) Formulation. The empirical definition of the simple ACOL model, derived above, does not account for unobserved heterogeneity. Because retention rates rise with tenure (see the discussion above), the underlying distribution of unobservable factors affecting retention behavior systematically changes as cohorts pass through decision points. The simple ACOL model does not capture this change. Consequently, if measured factors are correlated with this changing distribution of unobserved factors, the coefficients in the ACOL model are potentially biased.

The ACOL-2 model was first applied to the retention decisions of DoD civilians by Black, Moffitt and Warner (1990). The model developed here parallels theirs. The ACOL-2 (panel probit) formulation follows directly from this framework when one

[6]Note that individual characteristics, assumed to be correlated with an individual's taste for various job attributes, can be included in the model, presumably reducing the dispersion of the unobserved component.

explicitly provides greater structure to the unobserved component of the decision rule, $\gamma_{j,t}$. In particular, let this error term consist of two parts. The first is an individual-specific, permanent component, α_j, while the second is a transitory component, $\epsilon_{j,t}$:

$$\gamma_{j,t} = \alpha_j + \epsilon_{j,t} \ . \tag{7}$$

The decision rule, ignoring Z, becomes stay if and only if:

$$ACOL_{j,t} - \alpha_j > \epsilon_{j,t}. \tag{8}$$

Now, include the Z characteristics affecting the decision to stay, such that:

$$X_{j,t}\delta = \left(ACOL_{j,t}, Z_{j,t}\right)(1, \beta). \tag{9}$$

The decision rule becomes, stay if and only if:

$$Prob\left[X_{j,t}\delta - \alpha_j > \epsilon_{j,t}\right] = \int_{(X_{j,t}\delta-\alpha_j)}^{\infty} f(\epsilon_{j,t})\, d\epsilon_{j,t} \ . \tag{10}$$

With ϵ distributed normally with mean zero and standard deviation σ_ϵ, the probability that the individual stays in period t, given that the individual has stayed through period $t - 1$, is given by

$$\int_{(X_{j,t}\delta-\alpha_j)}^{\infty} f(\epsilon_{j,t})\, d\epsilon_{j,t} = F\left[\frac{-(X_{j,t}\delta - \alpha_j)}{\sigma_\epsilon}\right], \tag{11}$$

where F(...) is the cumulative distribution function of the standard normal random variable.[7] Then, the probability that an individual enters at t = 1, stays through T - 1 periods, and leaves in period T, is given by:

$$Q_T = \prod_{t=1}^{T-1}\left(F\left[\frac{-(X_{j,t}\delta - \alpha_j)}{\sigma_\epsilon}\right]\right) \cdot F\left[\frac{(X_{j,T}\delta - \alpha_j)}{\sigma_\epsilon}\right], \tag{12}$$

where Q_T is the probability that an individual who enters at t = 1 leaves in period T.

[7]Note that 1-F[-C]=F[C], by the symmetry of the standard normal distribution.

This is a one-factor, variance-components formulation, which has the following interpretation. When an officer arrives at a decision point, it is as if he/she draws an $\epsilon_{j,t}$ at random from a distribution with mean zero. This distribution is the same for all officers. Moreover, if the officer stays and comes to another decision point, he/she again draws randomly from the distribution $f(\epsilon_{j,t})$. This value will be uncorrelated with the previous draw. In addition, the officer has a "permanent" component, α_j, that remains constant across decision points. This component is distributed over all officers according to the density function $f'(\alpha)$, which is also assumed to be normal. An officer cohort's distribution of α's changes as officers pass through multiple decision points. Those with relatively greater preferences for Army service (higher α's) will tend to stay at higher rates, so that the distribution of α's for the remaining officers is censored.

For a cohort of officers who enter at period 1, the proportion who stay through period T-1, and then leave at T, is:

$$Q_T = \int_{-\infty}^{\infty} \prod_{t=1}^{T-1} \left(F\left[\frac{-(X_{j,t}\delta - \alpha_j)}{\sigma_\epsilon} \right] \right) \cdot F\left[\frac{(X_{j,T}\delta - \alpha_j)}{\sigma_\epsilon} \right] f'(\alpha_j)\, d\alpha_j \ , \qquad (13)$$

where $f'(\alpha)$ is the density function of α, with mean u_α. Now, if α and ϵ are independent, then

$$\sigma^2_\gamma = \sigma^2_\epsilon + \sigma^2_\alpha . \qquad (14)$$

Define the parameter:

$$\rho = \frac{\sigma^2_\alpha}{\sigma^2_\alpha + \sigma^2_\epsilon} = \frac{\sigma^2_\alpha}{\sigma^2_\gamma} . \qquad (15)$$

This parameter represents the correlation in the total disturbance term between successive time periods. Assuming that the transitory component of the error term, ϵ, is uncorrelated over time, this term represents the importance of the fixed component of "tastes," α, in explaining the pattern of retention rates over time. Also, define $g_j = (\alpha_j - u_\alpha)/\sigma_\alpha$, implying that $\alpha_j = u_\alpha + \sigma_\alpha g_j$.

Next, note that[8]

$$\sigma_\epsilon = \sigma_\gamma(1-\rho)^{1/2} \; ; \; \frac{\sigma_\alpha}{\sigma_\epsilon} = \left[\frac{\rho}{(1-\rho)}\right]^{1/2} . \tag{16}$$

Let the expression for the ratio of the standard deviation in the permanent component of the error to the standard deviation in the transitory component be denoted by "r." Further, let $y_{j,t} = 1$ for those who stay in period t, and $y_{j,t} = 0$ for those who leave in period t. The expression for the cohort survival rate to time T can now be rewritten as

$$Q_T = \int_{-\infty}^{\infty} \prod_{t=1}^{T} F\left[\frac{-(X_{j,t}\delta - u_\alpha)}{\sigma_\gamma(1-\rho)^{1/2}} - rg_j\right](2y_{j,t}-1) f'(\alpha_j)\, d\alpha_j \; . \tag{17}$$

Making additional substitutions for $f'(\alpha)$, one obtains

$$Q_T = \int_{-\infty}^{\infty} \prod_{t=1}^{T} F\left[\frac{-(X_{j,t}\delta - u_\alpha)}{\sigma_\gamma(1-\rho)^{1/2}} - rg_j\right](2y_{j,t}-1) \frac{1}{(2\pi)^{1/2}} \exp^{-g_j^2/2} dg_j \; . \tag{18}$$

The variable ρ measures the proportion of the variance in the error that is accounted for by individual-specific factors affecting retention rates (α). If it is positive, retention rates will tend to rise simply as a result of the sorting process, with those having a low "taste" for military life selecting themselves out at early decision points. The coefficient on the ACOL variable is equal to $1/(\sigma_\gamma(1-\rho)^{1/2})$. Hence, officers will be more responsive to pay differences (a) the lower the dispersion or variance in unmeasured factors, σ_γ, and (b) the greater is the systematic component of unobserved factors affecting officer retention (*i.e.*, the greater is ρ).

<u>Calculation of the ACOL Variable</u>

The most important explanatory variable in the model is the

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[8]To see this result, recall that

$$\rho = \frac{\sigma^2_\alpha}{(\sigma^2_\alpha + \sigma^2_\epsilon)} \; .$$

Solving this equation obtains the expression for $\sigma_\alpha/\sigma_\epsilon$. Also, one can rewrite the expression:

$$\rho = \frac{\sigma^2_\gamma - \sigma^2_\epsilon}{\sigma^2_\gamma} \; .$$

Solving this expression for σ_ϵ obtains the expression in the text.

return to the occupation, or earnings. In theory, ACOL equals the difference between expected military earnings and alternative civilian earnings (M - C) and the value of the non-pecuniary factors affecting retention, including the "taste" component. For the estimation model, however, tastes appear implicitly in the error term. Thus, the ACOL variable used here includes two elements: military and civilian earnings.

The economic theory of human capital implies that individuals choose a course of action that maximizes the net present value of returns over their remaining working lives. This concept has implications for determining the appropriate horizon for considering a job change. In other words, an individual will not change jobs to achieve a higher immediate wage if the net present value of returns over his/her lifetime is lowered, holding non-pecuniary differences constant.

The model is normalized by expressing returns as the difference between the returns to staying in the military and the returns to leaving immediately (hence, the "cost of leaving"). The pay variable is the difference between expected lifetime earnings if the individual stays until some optimal horizon and expected earnings if he/she leaves immediately. The determination of optimal horizon is discussed below.

The ACOL model is sometimes referred to as a "maximum regret" model.[9] It assumes that an individual will leave immediately only if $M_j - C_j < -Z\beta + \alpha_j + \epsilon_{j,t}$ for each $j = 1,2,...,30 - YOS$. This implies that an officer will stay if there is at least one horizon for which the returns to staying exceed the returns to leaving. The ACOL variable is defined as the maximum pay difference over all possible horizons.[10]

To calculate the ACOL variable, assume that an officer can stay in the military for a maximum of n more years, and will stay in the labor force T more years, regardless of when he/she leaves the Army.[11] Then, calculate the following variables for n possible horizons:

1. M_k = expected military pay in year k (k=1,2,...,n).

2. W_{k0} = future potential civilian earnings from leaving immediately (k=1,2,...,T).

[9]Arguden (1986), p. 30.

[10]Warner and Goldberg (1984), pp. 14-15. Note that the ACOL measure should be considered an index describing the financial incentive to stay at least one more year. The horizon associated with the maximum ACOL value is not necessarily the optimal leaving point.

[11]This specification of the pay variable is derived from Warner and Goldberg (1984), p. 27.

3. W_{kn} = future potential civilian earnings from staying n more years, where civilian wages are conditional on n years of military experience (k=n+1,n+2,...,T).

4. r = the personal discount rate.

5. $d^k = (1/(1+r))^k \quad (k=1,\ldots,T)$.

The *cost of leaving* (C_n) is the discounted stream of pay differences over the T-year horizon:

$$C_n=\sum_{k=1}^{n} M_k d^k + \sum_{k=n+1}^{T} W_{kn} d^k - \sum_{k=1}^{T} W_{k0} d^k. \tag{19}$$

Rearranging terms,

$$C_n=\sum_{k=1}^{n} d^k (M_k-W_{k0}) + \sum_{k=n+1}^{T} d^k (W_{kn}-W_{k0}). \tag{20}$$

This specification is valid for a generic specification of civilian earnings. The model that predicts civilian earnings in this study does not distinguish military from civilian experience in predicting future civilian earnings. Thus, $W_{k0} = W_{kn}$ and the last term drops out:

$$C_n = \sum_{k=1}^{n} d^k (M_k-W_{k0}). \tag{21}$$

Finally, the pay variable must account for the fact that the present value of pay received decreases with distance from the decision point. Thus, the annualized pay difference (A_n) is expressed as:

$$A_n = \frac{C_n}{\sum_{k=1}^{n} d^k}. \tag{22}$$

The ACOL value used in the estimation is

$$\max_{n} A_n = A_n^{*}. \tag{23}$$

where the horizon, n, maximizes the annuitized difference between military and civilian pay.

ECONOMETRIC MODEL

This section describes how the ACOL-2 model is applied to the problem of Army officer retention in this study. It describes the maximum likelihood equations, the numerical integration procedure and discusses the construction of the dependent and explanatory variables in the estimation model.

This model of officer voluntary stay-leave decisions includes up to eight decisions points for some officers. A decision point, for which a retention or hazard rate is estimated, is a year long interval over which the officer is assumed to be free to leave the Army, should he or she choose to do so. The first decision point is the year in which the officer's initial service obligation ends. This may be as early as the fourth year of service for some officers. The last decision point is at year of service eleven—the year prior to selection to Major for most officers. All officers in the sample are not observed through year of service eleven, of course. Some leave prior to reaching this point, and, in some instances, the period for which there is data ends prior to reaching this point.

This formulation, as a panel probit with annual, multiple decisions for the observations, differs from the formulation in Mairs, *et. al.* (1992). In the latter, the model was limited to two decision "windows." Each "window" was three years in length. An additional source of error was undoubtedly introduced because a given explanatory variable was forced to account for decisions over a much wider time period. The multiple decision panel probit formulation is undoubtedly preferred both because the potential for errors in the explanatory variables is reduced, and because the prediction of annual retention rates for junior officers will be more useful for policy.

Estimation of panel probit models with multiple decision points has been computationally impractical because of the necessity of evaluating multiple integrals. The formulation presented above reduces the problem to the evaluation of a single integral. However, it includes the product of several univariate normal probabilities. Butler and Moffitt (1982) have applied a numerical integration procedure based on Gaussian quadrature which reduces the computational burden.

Consider, again, the following equation:

$$Q_T = \int_{-\infty}^{\infty} \prod_{t=1}^{T} F\left[\frac{-(X_{j,t}\delta - u_\alpha)}{\sigma_\gamma(1-\rho)^{1/2}} - rg_j\right](2y_{j,t}-1)\,\frac{1}{(2\pi)^{1/2}}\exp^{-g_j^2/2}\,dg_j. \qquad (24)$$

Define $q^2 = g_j^2/2$, implying that $g_j = z(2)^{1/2}$. Then the expression for Q_T can be written as:

$$Q_T = \int_{-\infty}^{\infty} K_{jT}(q) e^{-q^2} dq \ , \qquad (25)$$

where

$$K_{jT} = \prod_{t=1}^{T} F\left[\frac{-(X_{j,t}\delta - u_\alpha)}{\sigma_\gamma (1-\rho)^{1/2}} - rg_j\right](2y_{j,t} - 1)\frac{1}{\pi^{1/2}} . \qquad (26)$$

This integral can be approximated by

$$Q_T = \sum_{h=1}^{H} k_h K_{jT}(q_h) . \qquad (27)$$

where H is the number of evaluation points, and the k_hs are the Hermite weights for approximating the integral at the evaluation points.[12] The expression in equation 27 is the contribution to the likelihood function for one individual observed across T decision points. Assume that the model is estimated for a sample of N officers. The log-likelihood function is expressed as:

$$\ln(L) = \sum_{n=1}^{N} \ln(Q_T) . \qquad (28)$$

Estimation Model

Previous research estimated a prototype, two-period model of U.S. Army officer retention in the Air Defense Artillery branch.[13] This study specifies and estimates a multi-period model for two additional branches, Infantry and Signal Corps. The major methodological issues included:

- officer branches to model
- definition of decision points, or windows

Each decision was crucial for providing information about how well the ACOL-2 approach may apply in a broader context.

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[12]Hermite integration is a form of numerical integration (or quadrature) that uses weighting coefficients and unequally spaced evaluation points. Allowing the evaluation points, or abscissas, to vary increases degrees of freedom, allowing one to approximate the integral fairly accurately with fewer evaluation points than in a traditional quadrature technique. For a further discussion, see Butler and Moffitt (1982).

[13]Mairs, *et. al.* (1992).

The Infantry (IN) and Signal Corps (SC) branches were selected for estimation in this analysis. Preliminary data analysis revealed sufficient time-series and cross-sectional variation in separations to allow estimation of pay and other effects. In addition, the IN branch is the largest officer branch and may provide valuable insights relevant for all combat-arms branches. Deputy Chief of Staff Personnel (DCSPER) officials also identified the SC branch as a community of particular concern.

Army officers' career experiences are the outcome of a professional development process in which retention (*i.e.*, labor supply) decisions are made by officers and performance-based promotion (*i.e.*, labor demand) decisions are made by the Army. The first point at which an officer may make a *voluntary* stay/leave decision is at his/her expiration of obligated service. In principle, separation may occur at any time from this point to the maximum retirement age. In practice, however, the financial incentives of the military retirement system cause separation rates after the twelfth year of service (and selection to Major) to fall towards zero.[14] An examination of loss records showed a large number of officers left the Army in year twelve. These separations occurred largely among Captains who were not selected for Major. It seems likely that separations in the twelfth year of an officer's career are due to demand conditions (*e.g.*, personnel policy) rather than voluntary supply decisions.[15] Consequently, the analysis focuses on behavior between the end of an officer's initial obligation and his/her eleventh year.

This period may span from six to eight years, because an officer's initial obligation depends on source of commission and whether the officer received financial aid for education from the Army. Officers reach important career decision points—including the Lieutenant Retention Board, the Captain Retention Board and Battery Command—during this time. The experience gained from this process provides valuable career information to officers considering a long-term career (*i.e.*, at least twenty years) in the Army.

Thus, the decision period modeled in this analysis includes a maximum of eight years per officer. Most officers have fewer than eight, either because of separations (censoring), longer initial obligations, or decision periods extending beyond FY90 (the last year observed in the data set). For example, Military Academy graduates incur five-year initial obligations. These officers may be observed at up to six decision points (YOS 6

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[14]Officers promoted to Major may remain on active duty until completion of twenty years of service, regardless of whether they are promoted further.

[15]It is also possible that some separations in years twelve through twenty are voluntary supply decisions, but most voluntary pre-retirement decisions occur before that point.

through YOS 11). Some Reserve Officer Training Corps (ROTC) and Officer Candidate School (OCS) graduates have initial obligations as small as three years. These officers may be observed at up to eight decision points (YOS 4 through YOS 11). Table 1 shows the distribution of initial obligations in the Infantry and Signal Corps samples.[16]

Table 1

Number of Observations by Branch and Initial Obligation

Initial Obligation	Infantry	Signal Corps
3	2552	1676
4	677	644
5	1152	303
Total	4381	2623

Dependent Variables. The observed dependent variables were set equal to 1 if an individual remained on active duty for that decision year, and equal to zero if the individual separated at any time during the year. Censored and unobserved decisions were assigned a value of 0.5 in the equation.

Pay Variables. This section describes the computation of the ACOL variable, beginning with definitions of military compensation and civilian earnings.

Military compensation includes Basic Pay, Basic Allowance for Subsistence (BAS), Basic Allowance for Quarters (BAQ) and Variable Housing Allowance (VHA). The sum of these elements is defined as Regular Military Compensation (RMC). RMC depends on an officer's YOS, pay grade and dependent status. The definition of YOS adopted here assumes uninterrupted service—an officer's years of service for horizon year *i* is his/her current *YOS* + *i*. Expected pay grade is imputed by constructing weighted YOS vectors for each pay element. For example, the RMC vector for FY83 is the product of the FY83 RMC table and a table of the percentage of officers in each grade by YOS. This percentage is constructed from branch-specific inventories for each fiscal year. The housing allowance component of RMC is estimated as a weighted average of housing allowances for officers with and

[16]Determination of initial obligation is discussed in the next section (DATA).

without dependents.[17] No distinction is made between members who received cash allowances and those who received in-kind benefits (*i.e.*, government-supplied housing). Officers in government quarters are assumed to receive benefits equivalent to the foregone allowances.

Military compensation also includes the present value of retirement annuities. The value for any YOS in the member's horizon equals the increase in retirement pay from staying until that horizon year. The value is zero for YOSs less than or equal to 19; the values for YOSs 20 through 30 increase with rising vesting percentages and expected basic pay.

Changes also occurred in the retirement system during the period of analysis. Those officers who entered active duty before September 1980 fall under the original retirement plan. Under this system, the officer vested at the completion of 20 years of creditable service (the end of YOS 20). The retirement annuity associated with a given YOS i (20 or higher) is

$$Annuity = BPAY_i * i * 0.025 \ , \tag{29}$$

where $BPAY_i$ is basic pay after i YOS.

Thus, an officer retiring after 20 years receives 50% of basic pay, while he/she would get 75% after 30 years. The annuity increases annually to keep pace with the Consumer Price Index.

Officers enlisting after August 1980, but before August 1986, fall under a second retirement system. While their annuity is similar in terms of percentage of pay and vesting point, it is based on an average of their highest three years' basic pay:

$$Annuity = (High\ Three)_i * i * 0.025. \tag{30}$$

The final system pertains to officers entering active duty after July 1986.[18] While the vesting years are also 20 through 30, the percentages vary from 40% to 75%. For this case,

$$Annuity = (High\ Three)_i * (i * 0.035 - 0.3). \tag{31}$$

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[17] Officers who already had dependents at the decision point were expected to continue to have dependents. Officers without dependents, however, were assumed to have some positive expectation of acquiring dependents in future years. The model assumes that the probability of an officer remaining without dependents in YOS *i* equals the proportion of officers in YOS *i* without dependents to officers in *i* - *1* without dependents.

[18] Very few observations in the data set fall into this group, since the data include observations only through FY90.

Retirement benefits are also adjusted for inflation. The Cost of Living Adjustment (COLA) under the newest system is one percentage point less than the CPI from retirement until age 62. At 62, the annuity makes a one-time catch-up to recover the inflation losses. After catching up, it reverts to the "CPI - 1" adjustment, but converts the pay percentage to the original calculation ($[HighThree]_i * i * 0.025$).

Retirement pay is expressed in terms of present value. Officers are assumed to receive the annuity from retirement until death at age 72. Since the annuity should (theoretically) stay constant in real dollars, the present value of the stream of payments (at the time of retirement) equals

$$PV(Retirement) = Annuity * \frac{1}{r}\left[1 - \frac{1}{(1+r)^t}\right]. \qquad (32)$$

Here, r is the personal discount rate and t is the number of years for which the annuity is received.

The present value of military pay is defined for each horizon year (i) as the discounted sum of the estimates of RMC and retirement annuities from the decision year to year i.[19]

$$M_i = \sum_{n=1}^{i} \left[\frac{RMC_{nk}}{(1+r)^n} + PV(Ret)_i\right]. \qquad (33)$$

In this application, pay is expressed in constant FY83 dollars and the discount rate is 10%. Price-level adjustments are based on the annual percentage increase from October to October in the Consumer Price Index for all urban consumers.

The ACOL variable must also include an estimate of the earnings an officer expects in civilian occupations if he/she leaves the Army. Econometric models of post-service earnings are based on the economic theory of human capital. According to this theory, earnings in an occupation are a function of education and experience. Furthermore, earnings increase with experience at a decreasing rate. That is, the relationship between earnings and experience is concave; the log of earnings is usually specified as a quadratic function of experience.

[19]Special pays are not included in the definition of military compensation in this research. Special pays are an addition to RMC designed to compensate officers for the negative aspects of specific duty assignments (*e.g.*, danger, time away from families). One might reasonably argue that the value of expected special pays should be included in the calculation of the ACOL variable. It is not possible, however, to accurately determine—given the available data—whether officers are to receive special pays. Moreover, it is inappropriate to include such a pay if the corresponding non-pecuniary job aspect is not included in the retention equation as well.

Moreover, job-specific training and experience do not increase expected earnings in alternative jobs; only general human capital does so. Studies of veterans' post-service earnings support this hypothesis.[20] Because at least some of the training that officers receive is military-specific, military experience is expected to yield a lower return than civilian experience. Further, officers who leave the Army change careers; this also contributes to lower expected earnings.

Variation in civilian earnings captures two effects: differences between individuals and changes over time that affect every worker in the same way. The sources of individual-specific differences include measured factors (*e.g.*, education, experience, occupation and demographic characteristics) and unmeasured factors related to ability.[21] Variations over time, on the other hand, are the result of changes in labor-market demand and supply conditions that affect wage rates earned by all workers. Civilian earnings predictions in a time-series, cross-sectional model such as this study require two types of information—an equation that predicts earnings as a function of experience and personal characteristics (*e.g.*, demographic variables and educational level); and an index that tracks changes in real wage levels across the period of analysis.

Models of civilian earnings for military personnel are often estimated using data for individuals with previous military experience.[22] These models combine civilian-sector earnings data (either from IRS or Social Security) with personal and service data. The advantage of using veteran's earnings data is that it measures the earnings potential of the sub-population relevant to this study. Accession into the military means that individuals undergo some degree of selection, censoring of tastes for the military and screening of qualities and talents. Further, such data provide the basis for separate estimates of the returns to civilian experience and military experience. These data may introduce bias, however, because they measure the civilian earnings of personnel who elected to leave the military. Members of a cohort who stay do so because they have a stronger preference for military service and/or they face lower earnings prospects in civilian jobs than do officers who leave. Under these circumstances, data for veterans may overestimate the earnings opportunities of officers who stay.

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[20]Goldberg and Warner (1987). See also Borjas and Welch (1986).

[21]In many cases, the measured attributes, especially demographic factors such as gender or race, function as proxies for unobservable "taste" differences. In other cases, especially education and labor-market experience, the characteristics are productivity signals—the worker has undertaken an investment in acquiring a visible indicator of productivity.

[22]See Goldberg and Warner (1987), Borjas and Welch (1986), and Smith, *et. al.*, (1991).

The alternative selected for this study is Current Population Survey (CPS) data that provide a cross-section of the civilian workforce. The Bureau of the Census conducts the CPS for the Bureau of Labor Statistics (BLS). Census contacts about 600,000 households nationwide every month. Interviewers collect information from respondents on labor force and employment status, work experience, income and other data items.

The CPS Annual Demographic File (March of every year) provides microdata on civilian earnings and demographic information required by a civilian earnings model (including work experience, race, gender and age). It does not, however, include information on military versus civilian experience.

The civilian earnings equation estimated for this study is based on a random sample of 20,000 observations from the March 1979 CPS.[23] The civilian earnings equation specifies the natural logarithm of wages as a function of experience, experience squared, race, gender, and educational variable.

An alternative approach is to use the individual's own attributes (rather than sample means) to predict earnings. Previous researchers, however, have encountered problems when using structural estimates of civilian earnings in military retention models. For example, Hogan and Goon (1989), in a model of Air Force officer retention behavior, found that the coefficient on the ACOL variable is quite sensitive to the mix of other demographic variables included in the model when the civilian earnings equation also includes similar demographic variables. They found that earnings equations using the DOD IRS/Social Security separatee files created somewhat greater stability problems from this source than did earnings estimates using CPS data.

In Mairs, et. al. (1992) alternative specifications of the civilian earnings equations were estimated using CPS data. The coefficient on the ACOL variable was found to be sensitive to the inclusion or omission of other demographic variables, representing "tastes," when civilian earnings estimates reflected cross-sectional variation due to demographic differences. One interpretation is that the structural model is unable to discriminate between cross-sectional variation in retention rates that is due to differences in "tastes" correlated with differences in demographic characteristics and differences in retention that are due to differences in civilian earnings that are associated with differences in demographic factors. This fundamental identification issue led Mairs, et. al. to eliminate cross-sectional variation in civilian earnings due to demographic characteristics, and include demographic characteristics as separate variables in the retention equation. This method was

[23]The equation was re-estimated using March 1989 data to verify the results. After adjusting for changes in nominal wage levels, there was no significant difference between the two equations.

used in the present study. Table 2 lists the parameter estimates for the equation.

For each officer, expected civilian earnings were estimated based on the sample's mean values for the explanatory variables. Thus, earnings varied only by experience (or YOS). All earnings estimates were then inflated to FY83 dollars and adjusted for the real change in median CPS weekly earnings from 1979 to the appropriate year of analysis.

Table 2

Civilian Earnings Equation

Variable	Estimate	t statistic
Intercept	9.14	861.6
Experience	0.03	32.8
Experience^2	-0.0005	25.6
Female	-0.48	64.4
Non-white	-0.098	11.0
High School	0.19	23.0
Some College	0.31	30.9
Bachelors	0.47	41.1
Bachelors Plus	0.598	47.5
Engineer	0.232	11.3
Social Science	0.103	2.1

Other Explanatory Variables

The retention equation contains other explanatory variables that improve its accuracy. Demographic and service variables may help explain some of the unobserved taste differences among officers and reduce the random error component in the equation. The national annual average unemployment rate is also included as an explanatory variable to measure civilian employment opportunities and uncertainty.

The unemployment rate is expected to have a positive effect on the probability of staying. As the unemployment rate in the civilian sector increases, the probability of finding a job decreases. Thus, the expected value of civilian employment decreases and makes staying in the military relatively more attractive.

The demographic variables in the retention equation included dichotomous variables for race and gender. The race variable (NONWHITE) is defined as zero if the individual was Caucasian and one otherwise. The gender variable (FEMALE) is one if the officer is female and zero if he is male. Marital status at each decision point is also included and defined as one if an officer is married and zero if single.

Two dichotomous variables are also included for Source of Commission (SOC). One variable identifies Military Academy (ACADEMY) graduates, while the other denotes ROTC graduates (ROTC). The coefficients for the included variable estimate retention differences between Academy and OCS graduates, and ROTC and OCS graduates, respectively.[24] These differences may reflect the effects of several influences. For example, the initial distribution of "taste" for Army life may differ among officers according to the way in which they entered the Army. These estimates may also measure differences in retention probabilities because of differences in initial obligations by SOC. An alternative specification included dummy variables for length of initial obligation and yielded substantially similar results.

DATA

The data used in this analysis were extracted from ARI's Officer Longitudinal Research Data Base (OLRDB). The Manpower and Personnel Research Division (MPRD) developed the OLRDB to conduct research and studies on a wide range of officer issues. The data base tracks individual officers from FY79 to FY90 and contains information extracted from the Officer Master File (OMF), the Separation Officer Master File (SOMF) and the Master and Loss File (MLF) maintained by DMDC.[25]

Each record in the OLRDB data base includes career data for an officer during the twelve-year period. Separation and duty flags cover the period from FY70 through FY90. In addition, each record includes a core data set with the most recent values for key variables. While the entire OLRDB is maintained in flat-file (ASCII) format, the CORE data set is also available as a SAS data set.[26]

Data Issues

Significant issues arose in constructing the data set for this project. The most important issue was the determination of an officer's obligation. Unlike the enlisted personnel data bases, the OMF does not include a variable that indicates an officer's Expiration of Term of Service (ETS) date. Officers do not incur explicit reenlistment contracts. Instead, they must

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[24]The three SOC categories encompass all members of the sample; there were no Directly Appointed officers.

[25]Fu Associates, Ltd. (1990), p. 1.

[26]Fu Associates, Ltd. (1990), p. 7.

complete initial obligations of active-duty service in return for receiving training, education or scholarships. Further training and duty tours may incur additional obligations as well.

Conversations with members of the Deputy Chief of Staff, Personnel (DCSPER) staff revealed that the available data sources could not provide sufficient information to identify all service obligations. Additional obligations may be of varying length, and may run either consecutively to or concurrently with any existing obligations. The OMF does, however, contain a data item—the Program Procurement Number (PPN)—that provides some information about *initial* obligations. The PPN indicates the program under which each officer was commissioned. The OMF record may contain both a Current PPN (CPPN) and Previous PPN (PPPN). Officers who originally receive Other Than Regular Army (OTRA) commissions will be assigned new PPN codes if they are integrated into the Regular Army. Their original PPN codes will be saved as PPPN.

Each value of the PPN has a length of initial active obligation associated with it. For this analysis, an extract of the OMF was created containing each encrypted Social Security Account Number (MATCHCODE), CPPN and PPPN from the OMF and SOMF for FY79 through FY90. These files were used to append PPN codes to the OLRDB extracts and, thus, to imply initial obligations for each member of the estimation sample.

Other Data Sources

Other data used in this analysis include historical military pay tables from FY79 through FY90, adjusted to real 1983 dollars, and civilian earnings data, referred to previously, from CPS data provided by the Bureau of Labor Statistics (BLS). National average annual unemployment rates and changes in the Consumer Price Index for all urban consumers (CPI-U) also come from BLS.

Data Set Creation

Creation of the estimation data sets for the IN and SC branches consisted of several discrete steps. First, records on the OLRDB with a Basic Branch (BABR) of either IN or SC for any FY in the period of analysis were extracted to two separate ASCII files. These raw data files and the PPN files described above were downloaded from nine-track tapes to a personal computer. On the PC, PPN codes were appended to each record for every FY in which an officer was on active duty in the period of analysis.

The next processing step created an estimation data set from eligible records. PPN code, Date of Entry on Active Duty (EADC) and Fiscal Year variables were used to determine a period of eligibility (end of initial obligation through YOS 11) for each officer in the sample. If that period coincided wholly or partially with the period of analysis (FY79 through FY90) a record was generated for the estimation data set.[27] At this point, error-checking procedures eliminated records with invalid values for key variables (*e.g.*, Female IN officers, officers who switched branches during the observation period). Each record might contain observations for up to eight consecutive fiscal years. Additional variables were created by transforming OLRDB variables, calculating ACOL variables for each decision point and appending unemployment data. OLRDB separation flags were used to create the dependent variables. If the officer separated from active duty during a fiscal year, the dependent variable was coded 0 for that decision point. If the officer remained on active duty, the dependent variable equaled 1. Finally, if the decision point was unobserved, the dependent variable was set equal to 0.5.

The final processing step used GAUSS data utilities to create data files compatible with the econometric software used in the study.

Officer Sample Statistics

Tables 3 and 4 show sample means for key variables at each decision point for the Infantry and Signal Corps branches, respectively.

Table 3

Estimation Sample Means—Infantry Branch

	Decision Point							
Variable	1	2	3	4	5	6	7	8
N	4382	3304	2664	2316	1948	1691	1040	682
Ret. Rate	0.8165	0.8789	0.9388	0.9473	0.9620	0.9651	0.9692	0.9692
Year	84.4094	84.6916	85.1798	85.7936	86.2628	86.8539	87.4606	88.0147
ACOL	9686.26	10826.28	12203.88	13511.16	15104.64	17106.84	18177.14	20026.17
Unemp.	7.0501	7.2737	7.2952	7.1651	6.8196	6.3773	6.1114	5.8604
Married	0.5899	0.6707	0.7421	0.7867	0.8193	0.8380	0.8413	0.8578
No. Dep.	0.9439	1.1595	1.4137	1.6235	1.8578	2.0225	2.1750	2.3123
YOS	4.6803	5.7085	6.6956	7.6887	8.7017	9.7055	10.2125	11.0000
Female	------	------	------	------	------	------	------	------
Non-White	0.1426	0.1413	0.1464	0.1459	0.1453	0.1425	0.1846	0.1979
Academy	0.2636	0.2812	0.2763	0.2712	0.2767	0.2779	0.0000	0.0000
ROTC	0.6052	0.5932	0.5946	0.6002	0.5903	0.5860	0.8231	0.7801

[27]To generate a valid record, the officer record must show at least one fiscal year of active duty as a commissioned officer in the U.S. Army following the completion of initial obligation (as defined by PPN).

Table 4

Estimation Sample Means—Signal Corps Branch

Variable	Decision Point 1	2	3	4	5	6	7	8
N	2623	1860	1432	1200	967	780	514	339
Ret. Rate	0.7732	0.8468	0.9148	0.9325	0.9431	0.9692	0.9689	0.9764
Year	84.9024	85.3392	85.8205	86.4625	86.8976	87.3513	87.8444	88.4071
ACOL	11297.75	12314.42	13586.32	14853.45	16525.88	18413.59	19829.00	21632.27
Unemp.	7.0932	7.0961	6.9883	6.7539	6.4707	6.1726	5.9411	5.7242
Married	0.5547	0.6280	0.7102	0.7642	0.8025	0.8385	0.8444	0.8820
No. Dep.	0.9089	1.1339	1.3645	1.5708	1.7777	1.9910	2.0739	2.1858
YOS	4.4766	5.4317	6.4190	7.4250	8.4426	9.4628	10.1790	11.0000
Female	0.1761	0.1624	0.1432	0.1317	0.1138	0.1051	0.1304	0.1416
Non-White	0.2856	0.3161	0.3310	0.3392	0.3382	0.3359	0.3872	0.3894
Academy	0.1163	0.1231	0.1264	0.1317	0.1437	0.1538	0.0019	0.0029
ROTC	0.7472	0.7204	0.7032	0.6942	0.6763	0.6654	0.7763	0.7375

FINDINGS

Table 5 presents the estimation results for the Infantry Branch and Table 6 reports results for the Signal Corps. Coefficients marked with an asterisk are significant at least the 0.05 significance level.

Table 5

Retention Model Parameter Estimates—Infantry

Variable	Estimate	t statistic
Intercept	0.204*	2.007
Nonwhite	0.008	0.193
Female	-----	-----
Academy	-0.036	-0.701
ROTC	-0.058	-1.319
ACOL	0.000024*	4.914
Unemployment	0.048*	4.895
Marital Status	0.299*	10.154
ρ	0.536*	6.138
Log Likelihoods		
Full Model		-5,155.99
Restricted Model		-6,841.48
Likelihood Ratio		3,370.98
Goodness of Fit Measures:[a]		
Maddala's pseudo R^2:		0.5367
McFadden's pseudo R^2:		0.2464
Cragg and Uhler's pseudo R^2:		0.0533

[a]Pseudo-R^2 measures are necessary in the case of a non-linear estimation technique. Those used here are described in Maddala (1983), pp. 38-40.

Table 6

Retention Model Parameter Estimates—Signal Corps

Variable	Estimate	t statistic
Intercept	0.284*	1.926
Nonwhite	0.328*	7.227
Female	0.007	0.126
Academy	-0.400*	-4.793
ROTC	-0.450*	-6.968
ACOL	0.000044*	6.078
Unemployment	0.025*	1.972
Marital Status	0.177*	4.686
ρ	0.485*	3.654
Log Likelihoods		
Full Model		-3,288.05
Restricted Model		-3,866.90
Likelihood Ratio		1,157.69
Goodness of Fit Measures:[a]		
Maddala's pseudo R^2:		0.3568
McFadden's pseudo R^2:		0.1497
Cragg and Uhler's pseudo R^2:		0.0307

[a]Pseudo-R^2 measures are necessary in the case of a non-linear estimation technique. Those used here are described in Maddala (1983), pp. 38-40.

The estimates provide strong evidence in support of the ACOL-2 model of officer retention. Relative pay has a significant, positive impact on an officer's propensity to stay. Note that the pay variable is ACOL (which includes current and future compensation as well as retirement pay), not military pay. Likewise, an increase in the unemployment rate leads to an increase in the retention rate of officers. Perhaps most important, however, is that both estimates of the correlation coefficient (ρ) are large and statistically significant. This finding strongly supports the underlying notion of the ACOL-2 model: retention decisions depend on the outcome at earlier decision points because there are individual-specific differences in preferences for Army service among officers.

Gender did not have a significant impact on retention behavior in the Signal Corps sample (the Infantry branch does not contain any females). Other demographic and service-related variables—including SOC, race and marital status—did have an impact. In contrast, however, only the marital status variable showed a significant effect in the Infantry sample. The Infantry equation does not show any differential impact of race or SOC on retention behavior. One possible explanation is that the

Infantry sample has less variations in these variables than does the Signal Corps sample. Table 7 provides support for this assertion. The variation across SOC is generally greater for the IN branch than for the SC branch, mostly because the IN branch draws a greater proportion of its officers from the Academy.

Table 7

Sample Mean and Standard Deviation

Variable	Infantry Mean	Infantry Std. Dev.	Signal Corps Mean	Signal Corps Std. Dev.
Nonwhite	0.1426	0.3497	0.2856	0.4518
Academy	0.2636	0.4406	0.1153	0.3206
ROTC	0.6092	0.4888	0.7472	0.4346
OCS	0.1312	0.3376	0.1365	0.3433

Pay and Unemployment Effects

The coefficient estimates of the two key economic variables—compensation (ACOL) and unemployment—provide the behavioral basis of the model of officer retention. Direct interpretation of the estimates is difficult, however, because the marginal effects of the explanatory variables on retention probabilities are non-linear. Elasticities are computed to measure the effects of pay and unemployment on retention probabilities. The elasticity is defined as the percentage change in the retention rate with respect to a given percentage change in an explanatory variable. The pay elasticity is defined with respect to military pay. The elasticity in this case is the product of the elasticity of retention with respect to ACOL, and of ACOL with respect to military pay:

$$\epsilon_{r,milpay} = \epsilon_{r,ACOL} * \epsilon_{ACOL,milpay}. \tag{34}$$

The implied elasticities for pay and the unemployment rate are estimated by predicting the survival probabilities at each decision point for a "typical" member of each sample. A "typical" officer is defined by assigning mean unemployment values and modal values of key attributes (race, gender, age, YOS, SOC, etc.). These values are used first to generate a baseline ACOL value and then to predict survival rates to each decision point. Retention rates are inferred from adjacent survival rates, *i.e.*, the retention rate at decision point *i* is defined as:

$$R_i = \frac{S_i}{S_{i-1}}. \qquad (35)$$

The typical values used for comparison here were for a Caucasian, male, unmarried ROTC graduate in either the Infantry or Signal Corps branch. The resulting estimates of pay and unemployment effects are shown in Table 8.

Table 8

Pay and Unemployment Effects

Decision Point	Pay Elasticities Infantry	Pay Elasticities Signal Corps	Unemployment Elasticities Infantry	Unemployment Elasticities Signal Corps
1	0.167	0.396	0.137	0.094
2	0.108	0.259	0.095	0.063
3	0.087	0.196	0.076	0.044
4	0.074	0.142	0.064	0.028
5	0.061	0.109	0.057	0.027
6	0.053	0.093	0.045	0.019
7	0.046	0.066	0.034	0.010
8	0.040	0.049	0.026	0.003

The pay effects appear to be significantly larger for the Signal Corps sample than for the Infantry sample. At the first decision point, for example, a 10% increase in military pay relative to civilian pay (other things being equal) will result in about a 4% increase in Signal Corps retention rates, but only about 1.7% increase for Infantry retention. Infantry officers appear to be somewhat less responsive to pay changes. This gap narrows at later decision points, but Signal Corps pay responsiveness remains higher. The Infantry results are also smaller than previous results for other officer communities, including Army Air Defense Artillery and non-pilot Air Force.[28] Pay effects in both samples decrease with tenure; elasticities have fallen by about seventy percent in both samples by the sixth decision point.

Infantry unemployment effects are slightly larger than Signal Corps effects. At the first decision point a 10% increase in the civilian unemployment rate results in a 1.4% increase in first-decision retention for Infantry officers and a 1% increase in retention for Signal Corps officers. Unemployment effects decrease across decision points.

[28]See Mairs, *et. al.* (1992) and Hogan and Goon (1989), respectively for results.

The findings indicate that the retention decisions of Army officers in the IN and SC communities are responsive to changes in pay and unemployment. The magnitude of the response is less than that typically found for enlisted personnel.

The panel probit specification explicitly accounts for changes in the underlying distribution of unobservable factors (tastes) affecting retention at subsequent decisions when the retention rate changes for a given decision point. This is demonstrated by considering a cross-period pay elasticity—the percentage change in retention probability at the second decision with respect to changes in military pay at the first decision. This elasticity is estimated by simulating a 10% military pay increase, affecting officers at the first decision only. The results of this simulation are shown in Table 9.

Table 9

Cross-Decision Point Pay Elasticity

Decision Point	Infantry	Signal Corps
1	0.167	0.396
2	-0.0001	-0.013

A 10% increase in pay at the first decision leads to a 1.7% increase in the retention rate at that point and a very small decrease in retention at the second decision for Infantry officers. The difference is more dramatic in the Signal Corps example; the first-period "bonus" yields a 4% retention increase at the first decision point, followed by a 0.1% decrease at the second decision point. Moreover, simulation showed that the decreases persist through the remaining decision points, albeit with a declining impact. The pay increase at the first decision induces officers to stay who otherwise would have left. When these officers reach the second decision, they leave the Army because the pay increase is not maintained at the second decision. This reduces the overall retention rate at the second decision point.

Demographic Effects

Tables 5 and 6 provide estimates of the magnitude of the effects of factors correlated with "taste" for Army life, including marital status, race, gender and SOC. The estimates measure the difference between a typical officer possessing that attribute and an otherwise similar officer who does not. For example, the estimated effect of marital status shows the difference in retention probabilities between a single, Caucasian, male, ROTC officer and a married, Caucasian, male, ROTC officer. The findings concerning taste effects are as follows:[29]

- The first-decision retention rate of a single Infantry officer is 5.59 percentage points lower than a married officer. A single Signal Corps officer's retention rate is 4.78 percentage points lower than that of a married officer.

- The probability that a non-Caucasian Signal Corps officer will elect to stay in the Army at the first decision point is 10.88 percentage points higher than an otherwise similar Caucasian officer. The effect of the race variable in the Infantry equation was statistically insignificant.

- The first-decision retention rate of Signal Corps Academy graduates is 1.81 percentage points higher than ROTC graduates.

- A Signal Corps OCS graduate has a first-decision retention rate that is 14.29 percentage points higher than ROTC graduates.

Alternative Specifications

Alternative versions of the officer ACOL-2 model reported above have been estimated in order to examine the effect of changes in the specification of the model on predicted behavior. In particular, the sensitivity analysis focused on the effects of: (a) controlling for unobserved heterogeneity, (b) alternative specifications of the explanatory variables, and (c) allowing for different models by Basic Branch (Infantry vs. Signal Corps).

The ACOL-2 model accounts for self selection among officers by estimating the correlation in unobserved taste components (*i.e.*, ρ) between consecutive retention decisions. According to this specification, officers who reach decision i have, on average, a stronger preference for service than officers making decision $i - 1$. Failure to control for the unobserved taste effects may bias estimates of pay effects upward—if one erroneously assumed no correlation in unobserved tastes, the reported coefficient of the ACOL variable would overstate the impact of pay on the probability of staying.

There are two possible tests for the presence of unobserved, fixed effects. The first is a simple t test on the estimated correlation coefficient. For both the IN and SC samples, the t test statistic allows one to easily reject the null hypothesis that ρ equals zero. Another approach is to re-estimate the

[29]Results are reported only for statistically significant effects.

model as a simple, pooled probit.[30] Table 10 reports the pooled probit estimates alongside the original results from Tables 5 and 6. Coefficients marked with an asterisk are significant at least the 0.05 significance level.

Table 10

Comparison of Pooled Probit and Panel Probit Results

Variable	Infantry Sample Pooled	Infantry Sample Panel	Signal Corps Sample Pooled	Signal Corps Sample Panel
Intercept	-0.42935*	0.204564*	-0.32510*	0.284315*
Nonwhite	0.01635	0.007707	0.32230*	0.327801*
Female	-------	--------	0.24865*	0.007123
Academy	-0.24122*	-0.036297	-0.54128*	-0.399576*
ROTC	-0.10259*	-0.057831	-0.47135*	-0.449702*
ACOL	0.00009*	0.000024*	0.00011*	0.000044*
Unemployment	0.07595*	0.048392*	0.02425*	0.024772*
Marital Status	0.30106*	0.298600*	0.19025*	0.177184*
ρ	-------	0.536016*	-------	0.484829*

Table 9 strongly supports the existence of fixed effects in these samples. The coefficient on ACOL increased significantly in both samples for the pooled probit. For the IN sample, the ACOL coefficient increased more than four times (from 0.00002 to 0.00009), while the increase in the SC sample was almost as large (from 0.00004 to 0.00011). Other differences in the results include an increase in the unemployment effect for the IN sample when ρ is omitted. The SOC effects also became significant in the IN sample—both ROTC and Academy graduates were less likely to stay in the Army than were OCS graduates. For the SC sample, the major change was in the gender variable—the coefficient became significant and much larger in the pooled probit specification.

Figures 1 and 2 compare the observed retention rates by decision point with the predicted retention probabilities for the IN and SC samples, respectively. In each case, the panel probit specification provides a better fit to the observed data than does the pooled probit model.

A final specification question addressed in this analysis concerned the validity of estimating separate models by Basic Branch. This issue has important implications for the design of

[30]It can easily be shown that—in the special case where ρ = 0—the panel probit model reduces to a simple probit of the pooled decisions for each observation.

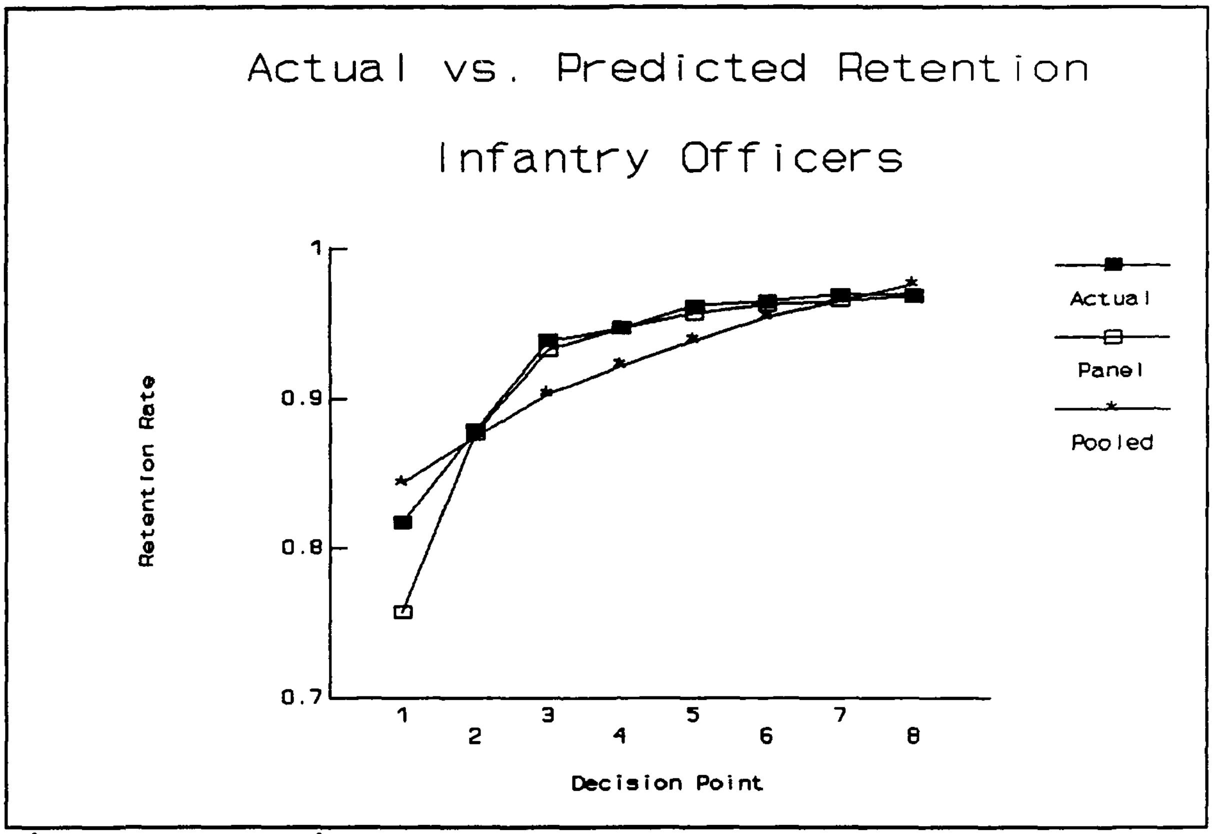

Figure 1. Predicted vs. observed retention (IN branch)

the Officer Personnel, Inventory, Cost, and Compensation (OPICC) model. Specifically, does retention behavior vary significantly across branches? If not, then an all-Army retention model should be sufficient to incorporate within OPICC for predicting policy effects.

The null hypothesis that branch does not matter for retention behavior was tested by pooling the IN and SC samples to estimate the econometric model (this has the same effect as restricting the model parameters to be the same across branches).

Then, the results were compared to the unrestricted model (*with* branch differences in the parameters). The unrestricted estimates are simply the original results presented in Tables 5 and 6. The proper test of the restriction is to perform a Likelihood Ratio test. The likelihood ratio is equal to the likelihood of the restricted model (L_R) divided by the likelihood of the unrestricted model (L_F). Moreover, the likelihood ratio test statistic (λ),

$$\lambda = -2*\left[\ln(L_R) - \ln(L_F)\right], \tag{36}$$

is distributed χ^2 with degrees of freedom equal to the number of restrictions (in this case, 8). The sums of the log-likelihoods

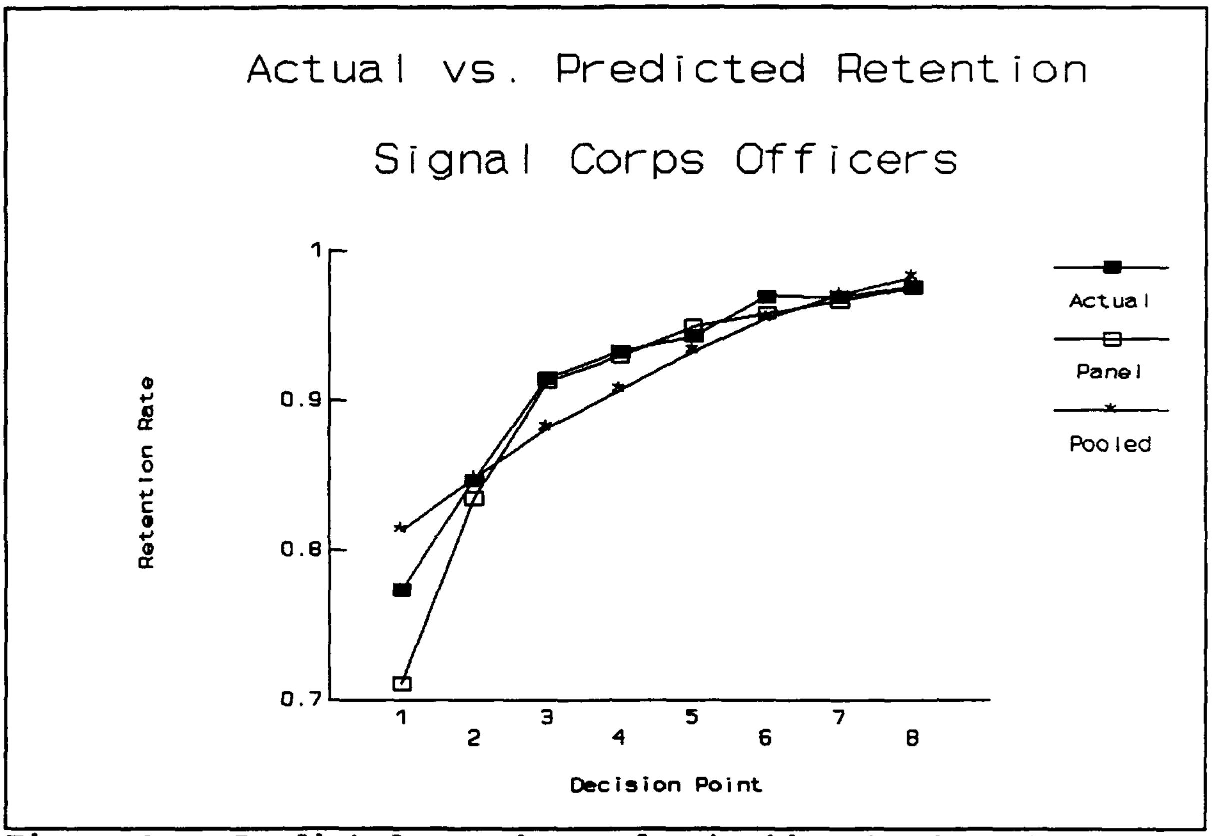

Figure 2. Predicted vs. observed retention (SC branch)

from the SC and IN branches were -3,281 and -5,156, respectively.[31] Thus, L_F = -8,437. The restricted model was estimated separately using a pooled data set. The log-likelihood for the restricted model equals -8,500. The likelihood ratio test statistic, using equation 36, equals 124.3. With eight degrees of freedom, the probability that the null hypothesis is true (the true parameters for the IN and SC are equal) is close to zero ($4.2 * 10^{-23}$). Thus, separate models by branch appear valid.

THE OFFICER PERSONNEL, INVENTORY, COST, AND COMPENSATION (OPICC) MODEL

The results of this study will be incorporated into a policy model for U.S. Army policy analysts. The proposed Officer Personnel, Inventory, Cost and Compensation (OPICC) model will incorporate the behavioral elements of this study in a PC-based inventory projection model. It will track the effects of changes in policy, compensation and economic conditions on the retention behavior of selected Army officer communities.

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[31] The log likelihood for the SC sample differs slightly from the value reported in Table 6. For this test, the SC model was reestimated without a dummy variable for gender (FEMALE) so that both samples had the same set of explanatory variables.

The key advantage of incorporating econometric findings into the inventory model is that these results provide quantifiable, reasonable estimates of changes in retention behavior caused by policy actions and changes in the civilian economy. The previous section of the report showed estimates of the impact, for example, of a ten-percent increase in military pay relative to civilian pay. The OPICC compensation policy module can construct similar comparisons for a wide range of policy scenarios. Thus, the analyst will be able to produce reasonable answers to such crucial policy questions as:

- What is the budget cost of a careerist bonus sufficient to retain an additional 100 officers?

- What are the cost and force-structure differences between a Voluntary Separation Incentive/Special Separation Bonus (VSI/SSB) program and 15-year retirement for achieving force reductions?

- How will a one-year promotion moratorium feed back into reduced career force flow?

- How will severe reductions in promotion opportunities affect out-year force structures? Will there be a sufficient number of qualified O-4s to meet even the reduced force requirement?

Uses of the OPICC Model

OPICC will serve as a desktop analytical tool for Army personnel managers. By incorporating econometric research and studies into a proven inventory-projection process, it will apply behavioral effects to various policy and economic scenarios. OPICC can then track the immediate and secondary effects of policy options.

The structure proposed here allows the model to track changes in compensation, unemployment and civilian earnings. Applying the ACOL-2 estimates from this study allows OPICC to adjust transition rates within the model to produce revised inventory projections. The model will also track changes in accession and promotion policies, as well as the budget cost implications of these changes. Future enhancements may include adding behavioral dimensions to the promotion and accession modules.

Proposed Structure of the Model

This section of the report presents a proposed design for the OPICC model. It is based on both the results of this study and on an examination of the Army's analytical needs for an officer personnel model. It is not intended to be the final blueprint for OPICC; rather, it serves as a basic structure with several optional features. The proposed design of the OPICC model is based on a modular structure. The modular design and development approach offers two advantages:

- Model development is easier to accomplish in incremental steps, subject to resource limitations.
- The model retains a great deal of flexibility for future modifications, enhancements and extensions.

Figure 3 displays the top-level view of the OPICC model's proposed design. The key element is the inventory ager (process module), which interacts with the policy module to project the force through the period of analysis. The model's fixed data set contains starting inventories and transition rates generated from the latest actual personnel data. The inventory ager produces output data sets that are fed to both the report generator and the cost module. The cost module, in turn, is linked into the structured cost data base of the Army Manpower Cost System. The following sections discuss the key features of each module.

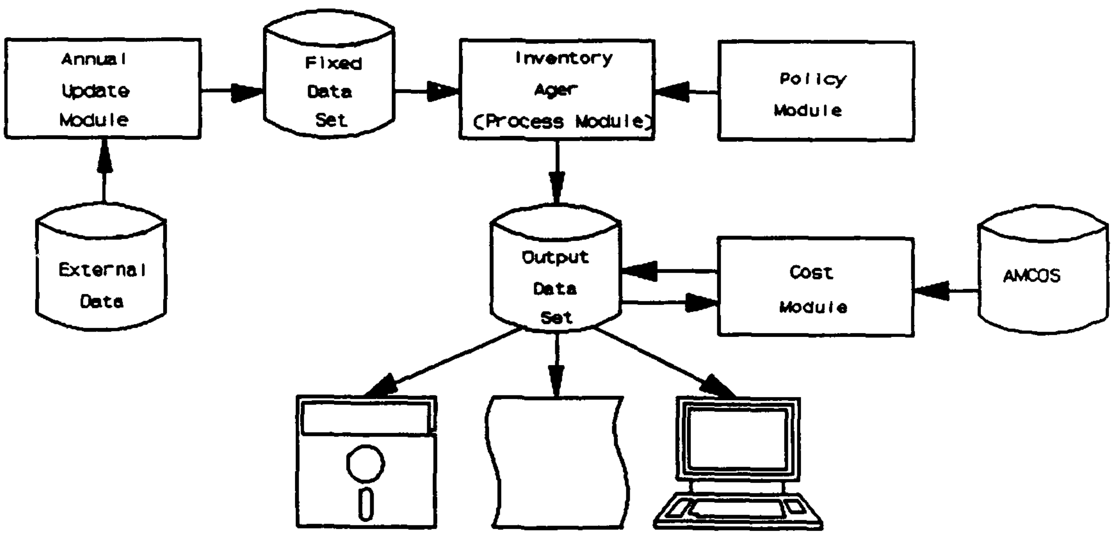

Figure 3. OPICC model proposed design-top-level view

The **Fixed Data Set Module** provides the starting force for each analysis. The Fixed Data Set (FDS) contains the most recent fiscal year's inventories and transition rates for the officer communities included in the model.[32] It also includes the military pay tables for that fiscal year and civilian-sector economic data. These data pass through the OPICC Data Base Management System (DBMS) and are screened through a Force-Definition function according to user-provided options. The DBMS is merely a "key" to the raw data in the FDS; it interprets the force-definition instructions to produce inventory matrices,

[32]The definition of communities to be modeled is discussed below.

starting transition rates (*e.g.*, retention rates) and baseline pay levels (military and civilian) for the projection. These instructions may include the community to be modeled (all-Army, IN branch, etc.) or force dimensions to be tracked during the projection.

The **Policy Module** is the other source of input for the analysis. It is in this module that the user provides the parameters to describe a policy scenario. While the module will contain a wide range of parameters, all will have default values; thus, the analyst must only edit those parameters relevant to a particular policy question. The processes modeled in this module may include:

- *Define compensation/economic environment*—including changes in military and civilian pay, special pays and bonuses, retirement and separation pays, unemployment, and inflation.

- *Set promotion policy*—define promotion zone by time-in-grade/time-in-service for each grade and projection year, set fill rates and selection rates and determine high-year tenure rules.

- *Set endstrength goals*—by grade and projection year.

- *Define accession policy*—set the number of officers accessed by Source of Commission and projection year, define total vacancy fill rate by projection year, and determine vacancy selection rate by SOC and projection year. Accession processes may differ by SOC (*e.g.*, Academy graduates accessed according to supply, OCS fills according to remaining vacancies).

The **Process Module** uses the baseline data from the FDS and run parameters from the Policy Module to project force levels, losses, gains and promotions across the projection period. Starting retention rates are adjusted using the econometric parameters from this study to account for changes in pay and economic conditions as specified in the Policy Module. Then, the force is transitioned across the YOS dimension (aged) using the adjusted retention rates. The remaining force consists of voluntary stayers in their end-year YOS cells.

This force is compared to endstrength goals to calculate vacancies by grade. The model then applies promotion rules to promote to vacancies. The promotion process must be top-down to allow for the vacancies generated by the promotion process itself. The model can allow for vacancy fill rates (percentage of vacancies to fill) lower or higher than unity. Moreover, the analyst may specify valid promotion zones by Time in Grade (TIG) or YOS. Finally, the promotion module will apply high-year tenure rules to involuntarily separate some officers. This occurs during the top-down promotion process to pass along the correct number of vacancies. The inventory matrix at this point consists of stayers in their end-year YOS, TIG and grade cells.

Finally, the Process Module accesses new officers into the inventory to produce end-year inventories. The module will allow the analyst to access officers by filling to vacancies, accessing user-specified levels or accessing at user-specified rates. Moreover, the accession method may vary by SOC. Academy graduates may continue to be accessed according to supply. The user might then specify that 50% of ROTC graduates receive active-duty commissions. Any remaining vacancies are filled by OCS graduates. End-year inventories also serve as begin-year inventories for the following projection year.

The **Output Module** stores and displays the results of a projection run. Its main functions are to generate reports to the screen, printer or output file and to maintain bookkeeping and archive information for outputs. This module may also allow the user to compare the differences between two different runs (a delta function) and to export results to other graphical or spreadsheet software. Output inventories are also used as inputs by the cost module (see below).

The **Cost Module** links the OPICC projection model with data from the Army Manpower Cost (AMCOS) officer model. It uses the OPICC output data and the AMCOS cost information to estimate the budget costs of a given scenario. It will take into account the cost implications of each scenario (*e.g.*, pay raises). Cost estimates are fed back to the Output Module's report generator.

The **Annual Update Module** is crucial to OPICC's continued usefulness. This part of the model contains routines and procedures for generating an updated FDS from the most recent year's personnel data (from the Officer Master File). At its most basic, the module may simply be a set of written procedures or instructions for the data base specifications. At its most automated, the module may process raw personnel data to create the FDS internally.

Model Design and Development Tradeoffs

Many variations and options are possible within the proposed OPICC structure. The model design and development process must include an evaluation of tradeoffs among these options in order to meet several constraints. Typically, a desktop model is subject to three constraints or "budgets": disk space, memory and processing speed. Practically, as well, any development project is constrained by the amount of available funds.

Design and development tradeoffs will be of two types: model dimensions and model features. Conceptually, the model dimensions should be determined by:

- the importance of that dimension to policy

- the differences in retention behavior by that dimension

In many cases, both reasons for including the dimension in the model apply. As dimensions are added, however, data requirements increase dramatically, as do memory requirements for the computer.

Consider a simple case of an inventory-projection model that simply has a YOS dimension. The projection matrix has 30 cells. Processing time would be relatively fast, the stored data would be small, and the process would easily fit within any computer's memory capacity. One might consider it appropriate, however, to add a grade dimension (*e.g.*, O1, O2,...,O6+), a gender dimension and a race dimension. The projection matrix has increased from 30 cells to perhaps over 1,000 cells (30 YOS * 6 Grade * 2 Gender * 3 Race = 1,080 cells).

Tradeoffs may be made by sacrificing some model detail, either using double-tracking techniques or simply omitting certain characteristics of the underlying population. Still other dimensions may be properly "fenced" into separate populations. For example, if the analyst is concerned with cross-branch differences, the model might model such differences sufficiently by containing separate branch samples rather than a branch dimension. If the primary issue, however, is cross-branch lateral transfers, such effects may only be tracked with a branch dimension.

Model features are also subject to tradeoffs. In this case, development resources must be shared among features that improve the model's ease of use and its flexibility. Often, increasing a model's "user friendliness" necessitates "locking" some model parameters, thereby inhibiting modeling flexibility. On the other hand, if the model is too difficult to manage, the analyst may not be able to accurately specify a run. The proper balance depends on the types of analysis required and on who will ultimately use the model.

The following section presents a development scheme constructed to make these tradeoffs efficiently. This plan develops OPICC modularly, allowing users to have a maximum amount of input into the process. In this way, design and development tradeoffs focus model resources where they are most needed.

This section presents a development strategy which builds the OPICC model in stages, such that each stage represents a modular increment to the OPICC. The first stage is intended to provide a "core" policy modeling capability. Essential functions of a basic inventory projection model, with a behavioral component for adjusting retention rates as a function of compensation, are provided. Subsequent increments provide additional functions, enhanced capabilities, and broader coverage of the officer community. They are provided in modular packages that build on the core system. Upon completion of each modular addition, new features or additional breadth are provided to the core system.

This approach to development offers a number of advantages. First, initial basic capability is offered relatively early in the development process, reducing the incubation period before the first usable product is available to the Army officer personnel management community. This is important, because many of the key officer personnel management and policy issues of the next ten years are being addressed now. Second, with early introduction of a basic, core model, the experience of the officer personnel management community in using the model can help guide further development increments. Third, this planned, incremental approach makes eventual expansion into a fully operational, enhanced system possible during a period of budget uncertainty.

The following modular increments are proposed in the staged development strategy:

A. **Core system.** This consists of the inventory projection model (the "ager" or process module), a policy module which includes the ability to adjust retention rates as a function of compensation policy, and a fixed data set to support the core model. A key initial design consideration is the dimension of the inventory model, as discussed in the previous section. A preliminary dimension set includes source of commission, time-in-service, pay grade, time-in-grade, and two demographic dimensions.

   The initial fixed data set, which would include begin-inventory levels by the model dimensions, and underlying sets of transition rates by those dimensions, should probably be constructed for an aggregate, or all-Army case. The policy module allows the user to set inventory and pay grade targets, specify accessions by source of commissioning (and length of initial obligation), and adjust retention rates both directly and through the ACOL model. A simple promotion logic would be included. The user would choose a promotion policy of promote to fill vacancies, or promote to a fixed rule ("opportunity").

   The following increments can be modified based on initial user experience with the core system, and comments and suggestions based on that experience.

B. **Additional Officer Branches.** This component represents an expansion of the model to include additional officer branches. There are two parts to adding the ability to project branch-specific results. First, an econometric model of retention behavior is estimated to obtain behavioral parameters specific to the branch. The parameters are included in the policy module. Second, basic data regarding beginning level inventories and underlying retention rates for the branch are estimated from personnel files and added to the fixed data set.

This module, of course, represents multiple potential increments. One, or several, additional branches can be included in a given package.

C. **Cost Module.** In this component, costs are added to the model using the structured cost data base developed as part of the Army Manpower Cost System. This system contains cost data by officer branch. Relevant parts of this data will be attached directly to the inventory flow model. As officers pass through various states, or nodes, represented by the inventory model, the cost flows they generate will be recorded. Pay and allowance, retirement costs, training and education costs, rotation costs, and other personnel costs are included. Unlike the AMCOS model, the costs generated will be personnel driven and dynamic. Training costs, for example, will not be amortized, as in AMCOS, but be equal to the actual costs incurred by the officer as he or she passes through a state in the officer career path where training costs are incurred.

Once the basic cost module is developed, costs that vary with relevant officer communities can be included simply by transferring the relevant cost elements from AMCOS to the cost module of OPICC.

D. **Enhanced Report Generation and Annual Update of the Fixed Data Set.** The first part of this package would automate the process of annually updating the Fixed Data Set. This automated update would be routinized as part of the process of refreshing the Officer Longitudinal Retention Data Base (OLRDB) with the most recent data. Key data elements included in the annual update are: begin inventory by grade, year of service, time-in-grade, demographic category, and branch; transition rates by similar dimensions; and end strength targets by pay grade.

A simple report generator is included as part of the "core" model. Invariably, as users apply the model, and additional capabilities are added, a more sophisticated report generator, with both fixed reports and reports that can be "designed" by the user, becomes important. The second part of this component would add a more sophisticated report generator, one that facilitated reports design by the user. This report generator would also perform baseline comparisons.

E. **Enhancements to the Policy Analysis Module.** This increment would provide enhancements to the Policy Analysis Module, in the following areas. First, a "feedback" loop from promotion to compensation and retention would be included, so that the effect of changes in promotion policy could be immediately reflected in pay and retention, which in turn would affect promotion rates. Second, the compensation portion of the Policy Module would be modified to (a) change the retirement multiplier and vesting points for retirement for various officer cohorts; and (b) automatically augment or reduce eligibility for various separation incentives (VSI/SSB) by officer branch, grade and year of service; and (c) add a lump sum retention bonus to compensation by grade, year of service and branch. Working through the ACOL variable and the retention parameters, these changes would affect retention rates. Third, this enhancement would provide a policy switch to set mandatory retirement rates and involuntary separation rates by branch, grade and year of service.

The core system would provide a basic policy analysis tool to help analyze issues and policies surrounding the behavior of the officer inventory in the aggregate.[33]

CONCLUSIONS

The findings presented here reinforce the pilot study's findings that unobserved factors related to preference for service play an important role in determining which officers stay in the Army. Moreover, financial incentives continue to exert a strong behavioral influence, although the strength of that influence varies by branch. Civilian labor market conditions, as measured by the unemployment rate, had a significant effect on career decisions. Gender, race, source of commission and marital status all showed significant effects as well.

ARI's Officer Longitudinal Research Data Base (OLRDB) served as the primary data source for this study. The OLRDB is a rich source of information on officer retention behavior, and of the demographic and institutional characteristics of the officer community. Additional information was appended to OLRDB records to increase the accuracy of estimates of officers' initial obligations. Compensation tables and economic data from the Bureau of Labor Statistics provided additional variables for the analysis.

The results have several important implications for policy and management of the officer force. Although Army officers in both the SC and IN branches respond to changes in relative pay

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[33]Note that a particular officer branch could easily be substituted for the all-Army version suggested here.

levels, attempts to reduce the size of the force may be hampered by continued sluggishness in the civilian economy. Financial incentives to leave active duty could be partially or wholly offset by increased pessimism about civilian employment opportunities.

Finally, the study also explored the feasibility of an analysis model able to incorporate these findings and produce reliable projections of the impact of proposed policies on the shape and size of the force. A proposed structure for the Officer Personnel, Inventory, Cost, and Compensation (OPICC) model consists of a basic inventory ager that allows policy modules to adjust transition rates using the econometric relationships of the ACOL-2 model. Other model features include a report generator and a fixed data set with automated annual updates, as well as a cost module to integrate data from the Army Manpower Cost System (AMCOS) data base. This final component will allow OPICC to estimate the budget impact of proposed policy actions. If OPICC development proceeds, several key decisions must be made regarding model dimensions and features. The structure presented here, however, emphasizes modularity to maintain as much flexibility for future enhancements as possible.

Further research and studies must also depend on the direction in which OPICC development will go. Depending on the model's design, further Army officer communities may be modeled in the panel probit framework. An all-Army sample may also provide important information. Other elements of OPICC will benefit from quantitative research and studies as well. This study did not address other important aspects of officer careers, including promotions, the effects of arduous and OCONUS duty, and the behavior of retirement-eligible officers. Also, further research and studies on civilian earnings opportunities may yield additional insights into the economic alternatives faced by Army officers.

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